U.S. DEPARTMENT OF ENERGY
DEPARTMENT-WIDE
FUNCTIONAL AREA QUALIFICATION STANDARD

MECHANICAL SYSTEMS FUNCTIONAL AREA QUALIFICATION STANDARD

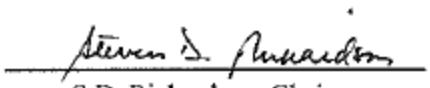
DOE Defense Nuclear Facilities Technical Personnel

U.S. Department of Energy
Washington, D.C. 20585

December 1999

APPROVAL

The Federal Technical Capability Panel consists of senior Department of Energy managers responsible for overseeing the Federal Technical Capability Program. This Panel is responsible for reviewing and approving the Qualification Standard for Department-wide application. Approval of this Qualification Standard by the Federal Technical Capability Panel is indicated by signature below.



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ACKNOWLEDGMENT

The Savannah River Operations Office is the Sponsor for the Mechanical Systems Functional Area Qualification Standard. The Sponsor is responsible for coordinating the development and/or review of the Functional Area Qualification Standard by subject matter experts to ensure that the technical content of the standard is accurate and adequate for Department-wide application for those involved in mechanical systems. The Sponsor, in coordination with the Federal Technical Capability Panel, is also responsible for ensuring that the Functional Area Qualification Standard is maintained current.

The following subject matter experts (SMEs) participated in the development and/or review of this qualification standard:

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U.S. DEPARTMENT OF ENERGY
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FUNCTIONAL AREA

Mechanical Systems

PURPOSE

The Department's Federal Technical Capability Program Policy, issued by the Secretary in December 1998, commits the Department to continuously strive for technical excellence. The Technical Qualification Program, along with the supporting technical Functional Area Qualification Standards, complements the personnel processes that support the Department's drive for technical excellence. In support of this goal, the competency requirements defined in the technical Functional Area Qualification Standards should be aligned with and integrated into the recruitment and staffing processes for technical positions. The technical Functional Area Qualification Standards should form, in part, the primary basis for developing vacancy announcements, qualification requirements, crediting plans, interviewing questions, and other criteria associated with the recruitment, selection, and internal placement of technical personnel. Office of Personnel Management minimum qualifications standards will be greatly enhanced by application of appropriate materials from the technical Functional Area Qualification Standards.

The technical Functional Area Qualification Standards are not intended to replace the U.S. Office of Personnel Management's (OPM) Qualifications Standards nor other Departmental personnel standards, rules, plans, or processes. The primary purpose of the Technical Qualification Program is to ensure that employees have the requisite technical competency to support the mission of the Department. The Technical Qualification Program forms the basis for the development and assignment of DOE personnel responsible for ensuring the safe operation of defense nuclear facilities.

APPLICABILITY

The Mechanical Systems Functional Area Qualification Standard establishes common functional area competency requirements for Department of mechanical systems personnel who provide assistance, direction, guidance, oversight, or evaluation of contractor technical activities impacting the safe operation of defense nuclear facilities. The technical Functional Area Qualification Standard has been developed as a tool to assist DOE Program and Field offices in the development and implementation of the Technical Qualification Program in their organization. Program and Field offices may choose to use this technical Functional Area Qualification Standard as-is, or they may use parts of it to facilitate the development of their own unique Technical Qualification Standards. In either case, satisfactory and documented attainment of the competency requirements contained in this technical Functional Area Qualification Standard, or similar Standards, ensures mechanical systems personnel possess the requisite competence to fulfill their functional area duties and responsibilities. Office/Facility-Specific Qualification Standards supplement this technical Functional Area Qualification

Standard and establish unique operational competency requirements at the Headquarters or Field element, site, or facility level.

IMPLEMENTATION

This technical Functional Area Qualification Standard identifies the technical competency requirements for mechanical systems personnel. Although there are other competency requirements associated with the positions held by mechanical systems] personnel, this Functional Area Qualification Standard is limited to identifying the specific technical competencies. The competency statements define the expected knowledge and/or skill that an individual must meet. Each of the competency statements is further explained by a listing of supporting knowledge and/or skill statements. **The supporting knowledge and/or skill statements are not requirements and do not necessarily have to be fulfilled to meet the intent of the competency.**

The competencies identify a familiarity level, a working level, or an expert level of knowledge; or they require the individual to demonstrate the ability to perform a task or activity. These levels are defined as follows:

> **Familiarity level** is defined as basic knowledge of or exposure to the subject or process adequate to discuss the subject or process with individuals of greater knowledge.
>
> **Working level** is defined as the knowledge required to monitor and assess operations/activities, to apply standards of acceptable performance, and to reference appropriate materials and/or expert advice as required to ensure the safety of Departmental activities.
>
> **Expert level** is defined as a comprehensive, intensive knowledge of the subject or process sufficient to provide advice in the absence of procedural guidance.
>
> **Demonstrate the ability** is defined as the actual performance of a task or activity in accordance with policy, procedures, guidelines, and/or accepted industry or Department practices.

Headquarters and Field elements shall establish a program and process to ensure that mechanical systems personnel possess the competencies required of their position. That includes the competencies identified in this technical Functional Area Qualification Standard or a similar Standard developed by the organization. Documentation of the completion of the requirements of the Standard shall be included in the employee's training and qualification record.

Equivalencies may be granted for individual competencies based upon an objective evaluation of the employee's prior education, experience, and/or training. Equivalencies shall be granted in accordance with the policies and procedures of the program or field office. The supporting knowledge and/or skill statements, while not requirements, should be considered before granting equivalency for a competency.

Training shall be provided to employees in the Technical Qualification Program that do not meet the competencies contained in the technical Functional Area Qualification Standard. Departmental training will be based upon appropriate supporting knowledge and/or skill statements similar to the ones listed for each of the competency statements. Headquarters and Field elements should use the supporting knowledge and/or skill statements as a basis for evaluating the content of any training courses used to provide individuals with the requisite knowledge and/or skill required to meet the technical Functional Area Qualification Standard competency statements.

EVALUATION REQUIREMENTS

Attainment of the competencies listed in this technical Functional Area Qualification Standard should be documented by a qualifying official or the immediate supervisor of mechanical systems personnel using any of the following methods:

- Documented evaluation of equivalencies
- Written examination
- Documented oral evaluation
- Documented observation of performance

CONTINUING EDUCATION, TRAINING AND PROFICIENCY

Mechanical systems personnel shall participate in continuing education and training as necessary to improve their performance and proficiency and ensure that they stay up-to-date on changing technology and new requirements. This may include courses and/or training provided by:

- Department of Energy
- Other government agencies
- Outside vendors
- Educational institutions

A description of suggested learning proficiency activities, and the requirements for the continuing education and training program for mechanical systems personnel are included in Appendix A of this document.

DUTIES AND RESPONSIBILITIES

The following are the typical duties and responsibilities expected of DOE defense nuclear facility technical personnel assigned to the mechanical systems functional area:

A. Review the management and oversight of the design and construction process.

B. Review contracting mechanisms (cost plus award fee, cost plus fixed fee, etc.) and contractor performance evaluations.

C. Serve as a subject matter expert and technical resource for mechanical systems personnel training and other technical matters.

D. Inspect or evaluate mechanical emergency systems for safe and efficient operation, maintenance and testing.

E. Participate in establishing and/or reviewing Department of Energy (DOE) orders related to mechanical system practices and requirements.

F. Evaluate contractor compliance with relevant DOE Orders, standards, codes, and Management and Operating (M&O) contractor operating procedures, etc.

G. Evaluate mechanical programs/operations/safety.

H. Review safety documentation.

I. Verify the application of quality assurance and safety principles to mechanical systems.

Position-specific duties and responsibilities for mechanical systems are contained in their Office/Facility-Specific Qualification Standard or Position Description.

BACKGROUND AND EXPERIENCE

The U. S. Office of Personnel Management's Qualification Standards Handbook establishes minimum education, training, experience, or other relevant requirements applicable to a particular occupational series/grade level, as well as alternatives to meeting specified requirements.

The preferred education and experience for mechanical systems personnel is:

1. Education:

   Bachelor of Science degree in Mechanical Engineering from an accredited institution or meet the alternative requirements specified in the Qualification Standards Handbook for the GS-0800, Professional Engineering Series

2. Experience:

   Industry, facility, operations, or other related experience and/or a Professional Engineer license that has provided a background in mechanical engineering. Specialized experience can be demonstrated through possession of the competencies outlined in this Standard.

REQUIRED TECHNICAL COMPETENCIES

Each of the competency statements defines the level of expected knowledge and/or skill that an individual must possess to meet the intent of this Technical Qualification Standard. **The supporting knowledge and/or skill statements further describe the intent of the competency statements but are not requirements.**

Note: When regulations or Department of Energy directives or other industry standards are referenced in the Qualification Standard, the most recent revision should be used.

1. Mechanical systems personnel shall demonstrate a working level knowledge of the basic components, operations, and theory of hydraulic systems.

Supporting Knowledge and/or Skills

a. Define the following terms and discuss their relationship in hydraulic systems:

- Force
- Work
- Pressure
- Receiver
- Accumulator
- Actuator

b. Describe the basic operation of a hydraulic system.

c. Discuss how energy in a hydraulic system is converted to work.

d. Discuss the purpose and basic construction of a hydraulic receiver.

e. Discuss the purpose and basic construction of a hydraulic accumulator.

f. Identify and discuss the hazards associated with hydraulic systems and their components.

g. Identify the characteristics and special hazards associated with phosphor-based hydraulic oil.

h. Using a cutaway diagram of a multi-port block valve, identify the flow paths and discuss its operation.

2. Mechanical systems personnel shall demonstrate a working level knowledge of the components, operation, and theory of pneumatic systems.

Supporting Knowledge and/or Skills

a. Define the following terms and discuss their relationship:

- Dew point

- Dehydrator
- Dew point indicator
- Actuator

b. Describe the basic operation of a pneumatic system.

c. Discuss how energy in a pneumatic system is converted to work.

d. Discuss the hazardous relationship between high pressure air and oil.

e. Identify and discuss the general hazards associated with pneumatic systems and their components.

f. Using a Piping and Instrumentation Diagram (P&ID) of a typical facility instrument air system, identify the main components to include:

- Compressor
- Dehydrator
- Receivers
- Unloader
- Relief valve

g. Using a cutaway diagram of a typical multi-stage air compressor, identify its main components and discuss their purpose and function to include:

- Prime mover
- High pressure (HP) stage(s)
- Low pressure (LP) stage(s)
- HP and LP suction and discharge valves
- Intercooler
- Aftercooler
- Cooling medium flow path(s)

h. State the purpose of an air compressor unloader and discuss its basic operation.

i. Using a cutaway diagram of a twin-tower pneumatic dehydrator, identify the flow paths and discuss its operation.

3. Mechanical systems personnel shall demonstrate a working level knowledge of safety and relief valves.

Supporting Knowledge and/or Skills

a. Define the following terms as they pertain to safety and relief valves:

- Set point
- Accumulation

- Blowdown
- Weep
- Simmer
- Pilot-actuated

b. Compare and contrast the purpose and operation of safety and relief valves.

c. Discuss how blowdown and accumulation are controlled in safety and relief valves.

d. Using a cutaway drawing of a safety valve, identify the main components to include:

- Seat
- Disc
- Blowdown ring
- Main spring
- Set-point adjustment mechanism

e. Discuss the methods used to test relief valves.

4. Mechanical systems personnel shall demonstrate a working level knowledge of a typical diesel engine including support systems.

Supporting Knowledge and/or Skills

a. Differentiate between two-stroke and four-stroke (two-cycle and four-cycle) engines.

b. Discuss the ignition principle in a diesel engine.

c. Discuss the purpose and principle of operation of a diesel engine injector.

d. Discuss the purpose of the following diesel engine support systems:

- Cooling water
- Lubrication
- Fuel oil
- Scavenging air
- Starting systems

e. Using a cutaway drawing of a typical diesel engine, identify and discuss the purpose of the major parts, including:

- Pistons
- Connecting rods
- Crank shaft

- Injectors
- Main bearings
- Cylinder liners
- Cooling water jackets

f. Discuss the purpose of a blower or turbo charger for a diesel engine.

g. Using a cutaway drawing of a typical diesel engine, identify the following systems and trace their flowpaths:

- Fuel oil
- Lubrication
- Cooling water
- Air

5. Mechanical systems personnel shall demonstrate a working level knowledge of the theory and operation of air conditioning and refrigeration (AC&R) systems.

Supporting Knowledge and/or Skills

a. Define the following terms as they apply to air conditioning and refrigeration systems:

- Latent heat of vaporization
- Latent heat of fusion
- Refrigerant
- Vaporization point
- Air and non-condensable gases

b. Using a one-line diagram of the basic refrigeration cycle, discuss the theory of operation of refrigeration systems.

c. Discuss the function of the following components of a typical refrigeration system:

- Compressor
- Condenser
- Thermal expansion valve
- Evaporator coils
- Receiver

d. Using a cutaway drawing of a typical thermal expansion valve and sensing bulb, explain its principle of operation.

e. Compare and contrast the principles of operation for centrifugal and reciprocating refrigeration compressors.

f. Discuss refrigerant leak detection.

g. Discuss the general hazards involved in handling refrigerants.

6. Mechanical systems personnel shall demonstrate working level knowledge of general piping systems and piping system maintenance.

Supporting Knowledge and/or Skills

a. Define the following terms as they relate to piping systems:

- Pipe schedule
- Water hammer
- Hydrostatic test pressure
- Laminar flow
- Turbulent flow

b. Discuss the potential hazards to personnel and equipment associated with water hammer.

c. Identify and discuss the typical causes of water hammer in piping systems.

d. Discuss the purpose of seismic restraints (whip restraints or snubbers) in piping systems.

e. Describe the principle of operation for the various methods of measuring piping system parameters (e.g., pressure, temperature, flow) to include:

- Resistance Temperature Detector (RTD)
- Differential pressure detector
- Pitot tube
- Thermocouple
- Bourdon tube pressure gauge
- Duplex pressure gauge
- Manometer

f. Discuss the purpose and operation of steam traps.

G. Identify and discuss different methods of pipe joining (threaded, bull weld, socket weld, etc.)

7. Mechanical systems personnel shall demonstrate a working level knowledge of the construction and operation of heat exchangers.

Supporting Knowledge and/or Skills

a. Describe the principle of operation for the following types of heat exchangers:

- Shell and tube
- Fin and tube
- Cooling tower

b. Define the following terms as they apply to heat exchangers:

- Tube sheet
- Tell-tale drain
- Parallel flow
- Counter flow
- Cross flow

c. Using a cutaway drawing of the following types of heat exchangers, show the flow paths of the cooling medium and the medium to be cooled:

- Parallel flow
- Counter flow
- Cross flow

d. Compare and contrast the following methods of tube to tube sheet connections:

- Rolled tube
- Packed tube

e. Explain the principle of operation of a forced-draft cooling tower.

f. Explain the principle of operation of a natural-draft (parabolic) cooling tower.

g. Explain advantages and disadvantages of down-draft versus cross-flow cooling towers.

8. Mechanical systems personnel shall demonstrate a working level knowledge of pump theory and operation.

Supporting Knowledge and/or Skills

a. Define the following terms as they relate to pumps:

- Head
- Net positive suction head
- Cavitation
- Shut-off head
- Run-out
- Centrifugal pump
- Positive displacement pump

b. Describe the general principle of operation for centrifugal pumps.

c. Describe the general principle of operation for positive displacement pumps.

d. Using a cutaway drawing of a centrifugal pump, identify the following components and discuss their purpose:

- Impeller
- Packing or mechanical seal
- Volute
- Lantern ring
- Wearing rings (impeller and/or casing)

e. Discuss Bernoulli's Law as it applies to the design and operation of centrifugal pumps.

f. Discuss why centrifugal pumps should always be started against a shut-off head.

g. Compare and contrast the principle of operation and typical pumped medium of the following types of positive displacement pumps:

- Reciprocating
- Rotary-screw
- Vane-axial

h. Using a cutaway drawing of rotary-screw positive displacement pump, identify and discuss the purpose of the following components:

- Driver screw
- Idler screw(s)

i. State the dangers to personnel and equipment associated with starting a positive displacement pump against a shut-off head.

j. Using the following list of system and/or pumped medium characteristics, identify which type of pump (e.g., centrifugal, reciprocating positive displacement, rotary-screw positive displacement) is best suited for the application.

- Slurries
- Fluids with high viscosities
- Low volume, high head
- Low head, high volume
- Water
- Oil

k. Discuss the concept of pump cavitation and describe its harmful effects.

l. Discuss the methods available (ultrasound, infrared, etc.) for monitoring pump cavitation.

9. Mechanical systems personnel shall demonstrate a working level knowledge of the general construction, operation, and theory of valves.

Supporting Knowledge and/or Skills

a. Define the following terms as they relate to valves:

- Disc
- Seat
- Throttle
- Actuator
- Bridgewall mark

b. Using a drawing of a valve, identify which of the following general types of valve it is and, describe its normal design application in a piping system:

- Gate
- Globe
- Ball
- Check
- Butterfly
- Regulating/reducing

c. Discuss why the design of a globe valve enables it to throttle fluids efficiently.

d. Using a diagram of a globe valve body showing the bridgewall mark, identify how the valve must be oriented in the system related to flow.

e. Discuss why gate valves, ball valves, and butterfly valves should never be used to throttle flow.

f. Discuss how cavitation occurs in valves and state any harmful effects that can result from cavitation.

g. Describe the construction and principle of operation for the following types of valve actuators:

- Manual
- Electric
- Solenoid
- Pneumatic
- Hydraulic

h. Describe the principles of operation and applications for modulating and pressure reducing valves.

10. Mechanical systems personnel shall demonstrate a working level knowledge of strainers and filters.

Supporting Knowledge and/or Skills

a. Compare and contrast the design, operating characteristics, and applications of filters and strainers.

b. Describe the following types of strainers and filters, including an example of typical use for each:

- Electrostatic filters
- Cartridge filters
- Precoated filters
- Bucket strainers
- Deep-bed filters
- High efficiency particulate (HEPA) filters
- Duplex strainers

c. Discuss the principle application of high efficiency particulate filters.

d. Identify and describe the hazards associated with high efficiency particulate filters, including any fire safety concerns.

e. Discuss how to determine the appropriate high efficiency particulate filter flow.

11. Mechanical systems personnel shall demonstrate a working level knowledge of the basic construction, operation, and theory of heating, ventilation, and air conditioning systems (HVAC).

Supporting Knowledge and/or Skills

a. Using a one-line diagram of an heating, ventilation, and air conditioning system, identify the following components and discuss their purpose:

- Blowers
- Fans
- Dampers
- Chillers
- Filters
- Heat exchangers
- Scrubbers
- Hoods
- Pressure sensors

b. Compare and contrast the design, operation, and application of axial-flow and radial-flow fans.

c. Discuss the relationships between the following in heating, ventilation, and air conditioning systems:

- Supply ventilation
- Flow
- Exhaust ventilation

d. Describe the purpose of the heating, ventilation, and air conditioning system in the following applications:

- Hoods
- Glove boxes
- Hot cells
- Confinement systems

e. Identify and discuss when maintaining a negative heating, ventilation, and air conditioning system pressure is desirable.

12. Mechanical systems personnel shall demonstrate a working level knowledge of fluid mechanics.

Supporting Knowledge and/or Skills

a. Define the following:

- Temperature
- Pressure
- Dynamic viscosity
- Kinematic viscosity
- Specific volume
- Specific gravity
- Capillarity
- Cavitation
- Laminar flow
- Turbulent flow
- Uniform flow

b. Discuss the differences between Newtonian and non-Newtonian flow.

c. Describe the bulk modulus of elasticity and compressibility.

d. Describe the effects characterized by Pascal's law of fluid pressure.

e. Explain the equation of continuity as it applies to fluid flow.

f. Discuss the Reynold's number and how it is used.

g. Discuss pressurized and non-pressurized flow.

h. Discuss Bernoulli's equation as it applies to steady-state flow rate calculations.

13. Mechanical systems personnel shall demonstrate the ability to calculate flow rates in fluid systems.

Supporting Knowledge and/or Skills

a. Calculate flow rates using the following methods:

- Pressure gradient
- Equilibrium continuity
- Manometer
- Reynold's
- Prandtl's

b. For a compressible flow system, calculate the effects of a sudden stop in flow.

c. For a turbo-machinery flow system (i.e., pumps, valves, pressure vessel nozzles), calculate the pressure and temperature gradients.

14. Mechanical systems personnel shall demonstrate a working level knowledge of thermodynamics.

Supporting Knowledge and/or Skills

a. Define the following:

- Compression
- Isothermic
- Isentropic
- Adiabatic

b. Discuss entropy and enthalpy as they relate to mechanical systems.

c. Define and discuss the following:

- Carnot cycle
- Rankine cycle
- Vapor-refrigeration cycle
- Otto cycle
- Gas standard cycle

d. Read and interpret a Mollier diagram.

e. Using data from a steady-state closed system, calculate the following:

- Entropy change
- Enthalpy change
- Pressure
- Temperature

f. Using data from a steady-state open system, calculate the following:

- Entropy change
- Enthalpy change
- Pressure
- Temperature

15. Mechanical systems personnel shall demonstrate a working level knowledge of steady-state heat transfer.

Supporting Knowledge and/or Skills

a. Define:

- Conduction
- Convection
- Radiation
- Thermal conductivity
- Convectivity
- Emissivity

b. Discuss Fourier's law.

c. Describe the factors that contribute to the co-efficient of thermal conductivity.

d. Discuss the principles for the determination of the temperature gradient for a slab.

16. Mechanical systems personnel shall demonstrate the ability to apply the principles of heat transfer.

Supporting Knowledge and/or Skills

a. Calculate the heat flux for one-dimensional, steady-state heat transfer through the following:

- Composite wall

- Series wall
- Parallel wall

b. Calculate the heat flux for transient conditions for heat transfer through the following:

- Composite wall
- Series wall
- Parallel wall

c. Using data, calculate total heat transfer and local heat flux in a laminar flow system.

d. Using data, calculate the Prandtl number for a laminar flow system.

e. Using data, calculate the log mean temperature difference for heat exchangers.

e. Using data, calculate emissivity, absorbity, and transmissivity.

17. Mechanical systems personnel shall demonstrate the ability to select appropriate components and materials in support of a mechanical system design or modification.

Supporting Knowledge and/or Skill

a. Differentiate between nuclear-grade and non-nuclear-grade ferrous and non-ferrous materials.

b. Discuss the differences between carbon steels and stainless steels.

c. Discuss how the following material properties affect performance in different applications:

- Corrosion
- Weight
- Erosion
- Strength
- Cost
- Reactivity
- Composition/alloy
- Ductility
- Brittleness
- Weldability
- Machinability

d. Identify and discuss the various methods of verifying the properties of selected materials, including:

- Rockwell hardness test
- V-notch test
- Drop-weight test

e. Discuss the differences in the material application standards promulgated by the following organizations:

- American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
- American Society of Testing Methods (ASTM)
- American National Standards Institute (ANSI)
- Society of Automobile Engineers (SAE)
- American Society of Mechanical Engineers (ASME)

f. Discuss the importance of traceability in nuclear system components.

18. Mechanical system personnel shall demonstrate a working level knowledge of the principles of lubrication.

Supporting Knowledge and/or Skills

a. Define:

- Viscosity
- Film thickness

b. Identify and discuss various types of lubricants to include:

- Oil
- Water
- Solids/powders
- Gaseous
- Grease

c. Discuss the Sabolt method of determining viscosity.

d. Using component vendor data, determine the proper class of lubricant for the component.

e. Discuss the hazards to equipment associated with mixing different types of oils.

19. Mechanical systems personnel shall demonstrate a working level knowledge of the following engineering design principles:

- **Value engineering**
- **Configuration management**

- **Systems engineering**
- **Reverse engineering**
- **Life cycle cost**
- **Maintainability**

Supporting Knowledge and/or Skills

a. Define:

- Value engineering
- Configuration management
- Systems engineering
- Reverse engineering
- Life cycle cost
- Maintainability

b. Describe the reverse engineering process and its benefits.

c. Describe how the principles of value engineering can be applied to mechanical systems projects.

d. Explain how life cycle costs are determined for a mechanical system and how those costs can be used.

e. Explain systems engineering principles and benefits.

f. Describe why maintainability must be considered in mechanical system design.

g. Discuss the principles and importance of configuration management.

20. Mechanical systems personnel shall demonstrate a working level knowledge of the safety and health fundamentals of mechanical systems and/or components.

Supporting Knowledge and/or Skills

a. Discuss the hazards associated with the use of corrosives (acids and alkalies).

b. Describe the general safety precautions necessary for the handling, storage, and disposal of corrosives.

c. Discuss the general safety precautions regarding toxic compounds.

d. Describe the criteria used to determine if a compound is a health hazard and discuss the ways toxic compounds may enter the body.

e. Discuss the general safety precautions regarding the use, handling, and storage of compressed gases, including hydrogen, oxygen, and nitrogen.

f. Explain the difference between a flammable material and a combustible material.

g. Describe the general safety precautions regarding the use, handling, and storage of flammable and combustible materials.

h. Identify and discuss elements of a mechanical safety program, including the following:

- Protective equipment
- Lockout and tagout
- Stored energy
- Component labeling

21. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the various computer applications used in mechanical systems engineering.

Supporting Knowledge and/or Skills

a. Identify and discuss at least one of the major computer codes used in mechanical systems modeling.

b. Discuss the application of computer-aided design (CAD) as it relates to mechanical system design.

c. Describe the use of computers in the monitoring and control of mechanical systems.

22. Mechanical systems personnel shall demonstrate a working level knowledge of mechanical diagrams, including:

- **As-built drawings**
- **Piping and Instrumentation Diagrams (P&ID)**

Supporting Knowledge and/or Skills

a. Using an engineering print, read and interpret the information contained in the title block, the notes and legend, the revision block, and the drawing grid.

b. Identify the symbols used in piping and instrumentation diagrams for:

- Types of valves
- Types of valve operators
- Types of eductors and ejectors
- Basic types of instrumentation.
- Types of instrument signal controllers and modifiers
- Types of system components (pumps, etc.)
- Types of lines

c. Identify the symbols used in piping and instrumentation diagrams to denote the location of instruments, indicators, and controllers.

d. Identify how valve conditions are depicted.

e. Determine system flowpath(s) for a given valve lineup.

f. Using a fluid power drawing, determine the operation, or resultant action of the stated component, when hydraulic pressure is applied/removed.

h. Discuss the origin and purpose of "as-built drawings."

23. Mechanical systems personnel shall demonstrate a familiarity level knowledge of chemistry fundamentals in the areas of corrosion and water treatment.

Supporting Knowledge and/or Skills

a. Explain the process of general corrosion of iron and steel when exposed to water.

b. Discuss the two conditions that can cause galvanic corrosion.

c. Discuss the following types of specialized corrosion:

- Pitting corrosion
- Stress corrosion cracking
- Crevice corrosion

d. Explain the ion exchange process.

24. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the concepts, theories, and principles of basic material science.

Supporting Knowledge and/or Skills

a. State the five types of bonding that occur in materials and their characteristics.

b. Compare and contrast the properties, characteristics and applications of stainless steel to those of carbon steel.

c. Discuss the following terms:

- Compressibility
- Stress
- Shear stress
- Tensile stress
- Compressive stress
- Strain

- Proportional limit
- Plastic deformation

d. Using the stress-strain curves for ductile and brittle material, identify the following points on a stress-strain curve:

- Proportional limit
- Ultimate strength
- Yield point
- Fracture point

e. Discuss the following terms:

- Strength
- Malleability
- Ductility
- Toughness
- Yield strength
- Hardness
- Ultimate tensile strength

f. Describe the adverse effects of welding on metal including the types of stress.

g. Discuss the phenomenon of thermal shock.

h. Discuss the following terms and discuss their relationship to material failure:

- Ductile fracture
- Brittle fracture
- Nil-ductility transition (NDT) temperature

i. Explain fatigue failure and work hardening with respect to material failure.

i. Discuss the affects of radiation on the structural integrity of metals.

25. Mechanical systems personnel shall demonstrate a familiarity level knowledge of reading and interpreting electrical diagrams and schematics.

Supporting Knowledge and/or Skills

a. Identify the symbols and/or codes used on engineering electrical drawings.

b. State the condition in which all electrical devices are shown, unless otherwise noted on the diagram or schematic.

c. Using a simple schematic and initial conditions, identify the power sources and/or loads and their status.

d. Using an electronic block diagram, print, or schematic, identify the basic component symbols.

e. Using a relay ladder, explain the logic ties.

26. Mechanical systems personnel shall demonstrate a familiarity level knowledge of reading and interpreting electrical logic diagrams.

Supporting Knowledge and/or Skills

a. Identify the symbols used on logic diagrams to represent the components.

b. Explain the operation of the three types of time delay devices.

c. Identify the symbols used to denote a logical "1" (or high) and a logical "0" (or low) as used in logic diagrams.

d. Using a basic logic diagram and appropriate information, determine the output of each component and the logic circuit.

27. Mechanical maintenance personnel shall demonstrate a familiarity level knowledge of maintenance management practices related to mechanical systems.

Supporting Knowledge and/or Skills

a. Define each of the following maintenance related terms and explain their relationship to each other.

- Corrective
- Planned
- Preventive
- Reliability Centered
- Predictive

b. Describe the elements of an effective work control program and the documentation used to control maintenance.

c. Discuss the importance of maintaining a proper balance of preventive and corrective maintenance.

d. Define the term "life limiting component" and discuss its impact on facility operation.

e. Identify typical maintenance performance indicators, and discuss their importance.

f. Discuss the relationship between maintenance and conduct of Operations, Qualify Assurance, and Configuration Management.

g. Discuss the requirements for the receipt and inspection of parts, materials, and equipment.

h. Describe the difference between temporary and permanent repairs/work and the requirements and controls in place to prevent inadvertent modifications.

28. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the principles and concepts of natural phenomena hazards and their effect on mechanical systems.

Supporting Knowledge and/or Skills

a. Discuss the potential impact on mechanical systems at defense nuclear facilities from the following natural hazards:

- Flooding
- Wind
- Tornado
- Earthquake and/or other seismic events
- Fire
- Lightning

b. Briefly describe the safety measures and design features commonly used as safeguards against natural hazards.

29. Mechanical systems personnel shall demonstrate a working level knowledge of requirements of Department of Energy (DOE) Order 420.1, Facility Safety.

Supporting Knowledge and/or Skills

a. Discuss the general design requirements of section 4.1.1, Nuclear Safety.

30. Mechanical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) Standard DOE-STD-1073-93, Guide for Operational Configuration Management Program.

Supporting Knowledge and/or Skills

a. Describe the purpose and objectives of the Operational Configuration Management Program.

b. Discuss what constitutes acceptable contractor compliance consistent with the requirements of DOE-STD-1073-93, Guide for Operational Configuration Management Program, for the following elements of the contractor's Configuration Management Plan:

- Program planning
- Equipment scope criteria
- Concepts and terminology
- Interfaces
- Databases
- Procedures

c. Discuss the following elements of the Configuration Management Program:

- Design requirements
- Document control
- Change control
- Assessments
- Design reconstitution adjunct
- Material condition and aging adjunct

d. Discuss the purpose, concepts, and general process for applying the graded approach to operational configuration management.

31. Mechanical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) Order 5000.3B, Occurrence Reporting and Processing of Operations Information.

Supporting Knowledge and/or Skills

a. State the purpose of the Order.

b. Define the following terms:

- Event
- Condition
- Facility
- Notification Report
- Occurrence Report
- Reportable Occurrence

c. Discuss the Department's policy regarding the reporting of occurrences as outlined in the Order.

d. State the different categories of reportable occurrences and discuss each.

e. Refer to Attachment 1 to DOE Order 5000.3B, Occurrence Reporting and Processing of Operations Information, and discuss the role of mechanical systems personnel in mechanical systems related reportable occurrences.

32. Mechanical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) Order 5480.21, Unreviewed Safety Questions.

Supporting Knowledge and/or Skills

a. Discuss the reasons for performing an Unreviewed Safety Question determination.

b. Define the following terms:

- Accident analyses
- Safety evaluation
- Technical Safety Requirements (TSRs)

c. Describe the situations for which a safety evaluation is required to be performed.

d. Define the conditions for an Unreviewed Safety Question.

e. Describe the responsibilities of contractors authorized to operate nuclear facilities for the performance of safety evaluations.

33. Mechanical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) Order 5480.22, Technical Safety Requirements (TSRs).

Supporting Knowledge and/or Skills

a. Discuss the purpose of Technical Safety Requirements,

b. Describe the responsibilities of contractors authorized to operate nuclear facilities for Technical Safety Requirements.

c. Define the following terms and discuss the purpose of each:

- Safety Limit
- Limiting Control Settings
- Limiting Conditions for Operation
- Surveillance Requirements

d. Describe the general content of each of the following sections of the Technical Safety Requirements:

- Use and Application
- Safety Limits

- Operating Limits
- Surveillance Requirements
- Administrative Controls
- Basis
- Design Features

34. Mechanical systems personnel shall demonstrate a familiarity level knowledge of Nuclear Safety Analysis Reports as described in DOE 5480.23, Nuclear Safety Analysis Reports.

Supporting Knowledge and/or Skills

a. Discuss the basic purposes and objectives of Nuclear Safety Analysis Reports.

b. Describe the responsibilities of contractors authorized to operate nuclear facilities regarding the development and maintenance of a Nuclear Safety Analysis Report.

c. Define the following terms and discuss the purpose of each:

- Design Basis
- Authorization Basis
- Engineer Safety Features
- Safety Analysis

d. Describe the requirements for the scope and content of a Nuclear Safety Analysis Report and discuss the general content of each of the required sections of a Nuclear Safety Analysis Report.

e. Discuss the uses that contractor management makes of Nuclear Safety Analysis Reports.

35. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the following Department of Energy (DOE) Standards and the Order related to natural phenomena hazards:

- **DOE-STD-1020-94, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities**
- **DOE-STD-1021-93, Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components**
- **DOE-STD-1022-94, Natural Phenomena Hazards Site Characterization Criteria**
- **DOE Order 5480.28, Natural Phenomena Hazards Mitigation**

Supporting Knowledge and/or Skills

a. Describe the purpose, scope, and application of the requirements detailed in the listed standards and the Order.

b. Discuss the graded approach process that Department line management uses to determine an appropriate level of coverage by mechanical systems personnel. Include in this discussion the factors that may influence the level of coverage.

c. Determine contractor compliance with the listed documents as they apply to contract design requirements and mechanical system activities at a Department defense nuclear facility.

36. Mechanical systems personnel shall demonstrate a familiarity level knowledge of DOE Order 5700.6C, Quality Assurance, as it applies to mechanical systems.

Supporting Knowledge and/or Skills

a. Describe the types of documents related to mechanical systems that should be controlled by a document control system.

b. Discuss the requirements for revision and distribution of controlled documents.

c. Discuss the determination of calibration frequency for mechanical test equipment.

d. Describe the effect of using inappropriate calibration standards on mechanical test equipment.

f. Discuss the key elements of the procurement process for mechanical systems as described in DOE 5700.6C, Quality Assurance.

37. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the codes and standards of the American Society of Testing and Materials (ASTM).

Supporting Knowledge and/or Skills

a. Discuss the following American Society of Testing and Materials documents and their relation to the design, construction, and/or modification of mechanical systems:

- ASTM A 312, Standard Specification for Seamless and Austenitic Stainless Steel Pipe
- ASTM G 46, Standard Practice for Examination and Evaluation of Pitting Corrosion

b. Describe the hierarchy of the mechanical rules, codes, Orders, and standards at defense nuclear facilities and explain where American Society of Testing and Materials standards fall within that hierarchy.

c. Discuss the applicability of the above American Society of Testing and Materials documents to DOE defense nuclear facilities.

38. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the codes and standards of the American Petroleum Institute (API).

Supporting Knowledge and/or Skills

a. Discuss API 650, Welded Steel Tanks for Oil Storage (Eighth Edition), and its relation to the design, construction, and/or modification of oil storage systems.

b. Describe the hierarchy of the mechanical rules, codes, Orders, and standards at defense nuclear facilities and explain where American Petroleum Institute standards fall within that hierarchy.

c. Discuss the applicability of the above American Petroleum Institute document to defense nuclear facilities.

39. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the codes and standards of the American National Standards Institute (ANSI).

Supporting Knowledge and/or Skills

a. Discuss the following American National Standards Institute documents and their relation to the design, construction, and operation of mechanical systems:

- ANSI N 8.3, Criticality Accident Alarm System
- ANSI N 12.1, Warning Symbols-Fissile Material Symbol
- ANSI N 13.1, Guide for Sampling Airborne Radioactive Materials in Nuclear Facilities
- ANSI N 16.5, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials
- ANSI N 510, Testing of Nuclear Air Cleaning Systems
- ANSI Z 358.1, Emergency Eyewash and Shower Equipment

b. Describe the hierarchy of the mechanical rules, codes, Orders, and standards at defense nuclear facilities and explain where American National Standards Institute standards fall within that hierarchy.

c. Discuss the applicability of the above American National Standards Institute documents to defense nuclear facilities.

40. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the codes and standards of the American Nuclear Society (ANS).

Supporting Knowledge and/or Skills

a. Discuss the following American Nuclear Society documents and their relation to the design, construction and operation of mechanical systems:

- ANS 8.1, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors
- ANS 8.7, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials
- ANS 8.9, Nuclear Criticality Safety Criteria for Steel Pipe Intersections Containing Aqueous Solutions of Fissile Material
- ANS 15.1, Development of Technical Specifications for Research Reactors
- ANS 59.1, Nuclear Safety-Related Cooling Water Systems in Nuclear Power Plants
- ANS 59.3, Safety-Related Control Air Systems
- ANS 59.51, Fuel Oil Systems for Standby Diesel Generators

b. Describe the hierarchy of the mechanical rules, codes, Orders, and standards at defense nuclear facilities and explain where American Nuclear Society standards fall within that hierarchy.

c. Discuss the applicability of the above American Nuclear Society documents to defense nuclear facilities.

41. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the codes and standards of the American Institute of Steel Construction (AISC).

Supporting Knowledge and/or Skills

a. Discuss the following American Institute of Steel Construction documents and their relation to the design and construction of mechanical systems:

- AISC M 011 (M016-89), Manual of Steel Construction Allowable Stress Design (Ninth Edition)
- AISC N 690 (S327-84), Nuclear Facilities - Steel Safety-Related Structures for Design, Fabrication, and Erection
- AISC S 326 (S328-86), Specification for Structural Steel Building Load and Resistance Factor Design

b. Describe the hierarchy of the mechanical rules, codes, Orders, and standards at defense nuclear facilities and explain where American Institute of Steel Construction standards fall within that hierarchy.

c. Discuss the applicability of the above American Institute of Steel Construction documents to defense nuclear facilities.

42. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the codes and standards of the American Society of Mechanical Engineers (ASME).

Supporting Knowledge and/or Skills

a. Discuss the following American Society of Mechanical Engineers documents and their relation to the design, construction, and/or modification of mechanical systems:

- ASME B 16, Fittings, Flanges, and Valves
- ASME B 31.1, Power Piping
- ASME B 31.3, Chemical Plant and Petroleum Refinery Piping
- ASME BPVC, Boiler and Pressure Vessel Code
- ASME N 509, Nuclear Power Plant Air Cleaning Systems
- ASME N 510, Testing of Nuclear Air Cleaning Systems
- ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities
- ASME NQA-2, Quality Assurance Program Requirements for Nuclear Facility Applications

b. Describe the hierarchy of the mechanical rules, codes, Orders, and standards at defense nuclear facilities and explain where American Society of Mechanical Engineers standards fall within that hierarchy.

c. Discuss the applicability of the above American Society of Mechanical Engineers documents to defense nuclear facilities.

43. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the codes and standards of the National Fire Protection Agency (NFPA).

Supporting Knowledge and/or Skills

a. Discuss the following National Fire Protection Agency documents and their relation to the design, construction, operation, and/or modification of mechanical systems:

- NFPA 11, Standard for Low-Expansion Foam and Combined Agent Systems
- NFPA 11A, Standard for Medium- and High-Expansion Foam Systems
- NFPA 13, Standard for the Installation of Sprinkler Systems
- NFPA 14, Standard for the Installation of Standpipe and Hose Systems
- NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection
- NFPA 16, Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems
- NFPA 17, Standard for Dry Chemical Extinguishing Systems
- NFPA 17A, Standard on Wet Chemical Extinguishing Systems
- NFPA 20, Standard for the Installation of Centrifugal Fire Pumps
- NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
- NFPA 50, Standard for Bulk Oxygen Systems at Consumer Sites

- NFPA 50A, Standard for Gaseous Hydrogen Systems at Consumer Sites
- NFPA 50B, Standard for Liquefied Hydrogen Systems at Consumer Sites
- NFPA 51, Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes
- NFPA 90A, Standard for the Installation of Air Conditioning and Ventilation Systems
- NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems
- NFPA 110, Standard for Emergency and Standby power Systems
- NFPA 111, Standard for Stored Electrical Energy Emergency and Standby Power Systems

b. Describe the hierarchy of the mechanical rules, codes, Orders, and standards at defense nuclear facilities and explain where National Fire Protection Agency standards fall within that hierarchy.

c. Discuss the applicability of the above National Fire Protection Agency documents to defense nuclear facilities.

44. Mechanical system personnel shall demonstrate a familiarity level knowledge of the inspection techniques described in NQA-1 and ASME Sections V and XI to include:

- **Ultrasonic test (UT)**
- **Visual inspection (VI)**
- **Magnetic particle test (MT)**
- **Dye-penetrant test (PT)**
- **Radiographic test (RT)**
- **Hydrostatic test (HT)**
- **Load test (LT)**

Supporting Knowledge and/or Skills

a. Describe the test methodology for each of the listed inspection techniques, including the expected degree of accuracy.

b. Discuss the advantages and disadvantages of each of the listed inspection techniques.

c. Identify and describe the usual application for each of the listed inspection techniques.

d. For each of the listed inspection techniques, identify and discuss the safety considerations and precautions that must be observed.

e. Identify the special hazards that are associated with radiographic testing and discuss how they are mitigated.

f. Identify the special qualifications needed by technicians performing each of the listed inspection techniques and discuss how those qualifications are achieved.

45. Mechanical systems personnel shall demonstrate the ability to communicate (both oral and written) when working or interacting with the contractor, stakeholders, and other internal and external organizations.

Supporting Knowledge and/or Skills

a. Identify the various internal and external groups with whom mechanical systems personnel must interface in the performance of their duties.

b. Apply written communication skills in the development of:

- Assessment reports
- Technical reports
- Technical papers

c. Apply effective and appropriate communications skills when providing specific work or task directions to contractors.

46. Mechanical systems personnel shall demonstrate a familiarity level knowledge of financial management practices and application of contractor resources to meet commitments to mechanical systems quality, safety, cost, and commitments.

Supporting Knowledge and Skills

a. Describe the process for preparing cost estimates and budgets.

b. Describe and contrast direct and indirect costs.

c. Define and explain the relationship between the following terms:

- Budgeted cost of work scheduled (BCWS)
- Budgeted cost of work performed (BCWP)
- Actual cost of work performed (ACWP)
- Earned value (EV)

d. Describe the types of Earned Value, and how they are measured.

e. Describe the types of data required to forecast cost and schedule performance.

f. Define the term "estimate at completion" (EAC).

f. Discuss the importance of formal change control in relation to project management.

47. Mechanical systems personnel shall demonstrate a familiarity level knowledge of program/project management practices and the application of contractor resources to meet commitments to mechanical systems quality, safety, cost, and schedule.

Supporting Knowledge and/or Skills

a. Explain the purpose of project management, and describe the life cycle of a typical project.

b. Describe typical documents and data sources utilized in project management.

c. Identify and explain the major elements of a project, and discuss their relationship.

d. Explain the purpose and use of a Project Management Plan (PMP).

e. Discuss the role of configuration management as it relates to project management.

f. Discuss the role of quality assurance as it relates to project management.

g. Explain the use of safety plans in the management of projects.

h. Discuss the relationship between work breakdown structure (WBS) and cost and schedule.

i. Describe the purpose and use of work packages and/or planning packages.

j. Describe the purpose of schedules, and discuss the use of milestones and activities.

k. Describe the critical path method of scheduling.

k. Explain the concept of a project management baseline and describe the cost, schedule, and scope baselines used in project management.

48. Mechanical systems personnel shall demonstrate the ability to perform project management duties as required to provide mechanical systems technical support to a project.

Supporting Knowledge and/or Skills

a. Support the preparation of a Project Execution Plan.

b. Evaluate a Work Breakdown Structure (WBS).

c. Evaluate a project's critical path schedule.

d. Using the results from an analysis of contractor noncompliance, determine the potential implications and describe how to communicate the results to contractor and Department management.

49. Mechanical systems personnel shall demonstrate a familiarity level knowledge of the Department of Energy/facility contract provisions necessary to provide oversight of a contractor's performance.

Supporting Knowledge and/or Skills

a. Describe the role of mechanical systems personnel in contractor oversight.

b. Compare and contrast the following:

- The Department of Energy's expectations of an Management and Operating (M&O) contractor.
- Management and Operating (M&O) contractor's expectations of the Department of Energy

c. Discuss the key elements and features of an effective Department of Energy and Management and Operating (M&O) contractor relationship

50. Mechanical systems personnel shall demonstrate a working level knowledge of assessment techniques (such as the planning and use of observations, interviews, and document reviews) to assess facility performance, report results, and follow up on actions takes as the result of assessments.

Supporting Knowledge and/or Skills

a. Describe the role of mechanical system personnel in the oversight of Government Owned Contractor Operated facilities.

b. Describe the assessment requirements and limitations associated with mechanical system personnel's interface with contractor employees.

c. Explain the essential elements of a performance-based assessment, including the areas of investigation, fact-finding, and reporting.

d. Explain the essential elements of a performance-based assessment including investigation, fact-finding, and reporting. Include a discussion of the essential elements and processes of the following assessment activities:

- Exit interviews
- Closure process
- Tracking to closure
- Follow-up
- Contractor corrective action implementation

d. Describe the actions to be taken if the contractor challenges the assessment findings and explain how such challenges can be avoided.

51. Mechanical systems personnel shall demonstrate the ability to assess contractor mechanical systems activities independently and make all necessary reports.

Supporting Knowledge and/or Skills

a. Using different sets of performance data, compare and contrast the data to highlight acceptable and unacceptable work performance.

b. Describe the methods by which noncompliance is determined and communicated to contractor and Departmental management.

c. Describe the role of mechanical systems personnel in the contractor performance evaluation process.

d. Participate in the evaluation of a contractor's performance.

e. Conduct an interview representative of one which would be conducted during an occurrence investigation.

f. Develop an assessment report.

g. Participate in formal meetings between Department management and senior contractor management to discuss the results of mechanical systems assessments.

52. Mechanical systems personnel shall demonstrate a working level knowledge of problem analysis principles and the ability to apply techniques necessary to identify problems, determine potential causes of problems, and identify corrective action(s).

Supporting Knowledge and/or Skills

a. Describe and explain the application of problem analysis techniques including the following:

- Root Cause Analysis
- Causal Factor Analysis
- Change Analysis
- Barrier Analysis
- Management Oversight Risk Tree (MORT) Analysis

b. Describe and explain the application of the following root cause analysis processes in the performance of occurrence investigations:

- Event and causal factors charting
- Root cause coding
- Recommendation generation

c. Using event and/or occurrence data, apply problem analysis techniques and identify the problems and how they could have been avoided.

d. Participate in at least one Type A, B, or C investigation.

e. Participate in at least one contractor or Department of Energy problem analysis and critique the results.

e. Using data, interpret two fault tree analyses.

53. Mechanical systems personnel shall demonstrate the ability to apply materials inspection techniques in the verification of mechanical system integrity.

Supporting Knowledge and/or Skills

a. Using system specifications, including a system diagram, determine the key information for a hydrostatic test on that system.

b. Using a work package, determine the appropriate tests needed to ensure proper installation of the mechanical system.

d. Using component information, describe the load tests required prior to lifting that component.

54. Mechanical systems personnel shall demonstrate the ability to evaluate contractor activities and reports controlled by DOE Order 5000.3, Occurrence Reporting and Processing of Operations Information.

Supporting Knowledge and/or Skills

a. Using an occurrence report and DOE Order 5000.3 as a reference, determine the following:

- The adequacy of the review process used
- Whether causes were appropriately defined
- Whether corrective actions addressed causes
- Whether the lessons learned were appropriate
- Whether corrective actions have been completed

b. Using an occurrence report involving mechanical systems activities, identify and discuss the factors contributing to the occurrence.

55. Mechanical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) maintenance management requirements as defined in DOE Order 4330.4B, Maintenance Management program.

Supporting Knowledge and/or Skills

a. Explain the Department of Energy's role in the oversight of contractor maintenance operations.

b. Identify the key elements of a contractor maintenance plan required by DOE Order 4330.4B, Maintenance Management Program.

c. Describe configuration control and its relationship to the maintenance work control process and the maintenance history file.

d. Describe the mechanisms for feedback of relevant information, such as trend analysis and instrumentation performance/reliability data, to identify necessary program modifications.

e. Review a contractor preventive maintenance activity and describe the preventive maintenance factors to be considered as the activity is planned.

f. Discuss the importance of post-maintenance testing and the elements of an effective post-maintenance testing program.

g. Review the results of post-maintenance testing activities and discuss the acceptance of post-maintenance testing.

h. Discuss the importance of maintaining a maintenance history.

i. Review a maintenance history file and discuss the potential implications of repeat maintenance items.

j. Explain the intent of a Maintenance Problem Analysis Program and discuss a maintenance problem where this program has been employed.

APPENDIX A
CONTINUING EDUCATION, TRAINING AND PROFICIENCY PROGRAM

The following list represents suggested continuing education, training and other opportunities that are available for mechanical systems personnel after completion of the competency requirements in this technical Functional Area Qualification Standard. It is extremely important that personnel involved with mechanical systems maintain their proficiency through continuing education, training, reading, or other activities such as workshops, seminars, and conferences. The list of suggested activities was developed by the Subject Matter Experts involved in the development of the Functional Area Qualification Standard and is not all-inclusive.

Based on the knowledge and experience of the Subject Matter Experts, it is suggested that two learning activities per year are necessary to maintain proficiency in the mechanical systems functional area after completion of the competencies in the Standard and other requirements of the Technical Qualification Program.